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Silos, Silage and Silage Crops for Hawaii.

By

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It has been the purpose of ranch owners and managers in Hawaii during recent years to put the business of beef-production upon a sound and scientific basis. To accomplish this different methods were tried. Some have divided their grazing areas into paddocks so that when any one area becomes closely cropped it is possible to allow it to rest and recuperate. Tame grasses have been introduced and planted upon many of the ranches with varying degrees of success. Improved pure-bred stock are in use for breeding, so that the quality of the produce is being gradually improved.

Yet when all this has been done there has been found to be something still lacking; there is still a weak spot in the system through which at times irreparable loss has occurred. The lands in use for ranching purposes are, necessarily, those unsuitable for the production of well paying cultivated crops. Because of high elevation, of rocky surface, of steepness, or of dry conditions, these lands are not arable and are of value only for grazing. Yet within the boundaries of each ranch there may be certain areas which, though limited in extent, are suitable for the production of tame forage at certain times of the year.

The weak spot in the system as heretofore managed has been

that there would be plenty of grass and forage at certain seasons when rains had occurred, but during the dry seasons and years, there would be great scarceness of feed and often a loss of many head of cattle.

To tide over this period of scarcity has been the problem of the ranchmen. There seems to be but two solutions to the problem: namely, prickly pear and silos. Drought resistant grasses have not been able to accomplish desired results. Although able to hold on, these grasses do not make sufficient forage during periods of drought. It is the purpose here to discuss only the question of silos and the use of silage as a means of overcoming this loss during dry seasons.

Silage is partly fermented green feed. The feed is placed in airtight pits or structures when in the green state and containing 75-85 per cent of moisture. The purpose of the silo is to retain the moisture and exclude the air. When placed in the silo the feed begins to ferment and get hot. Lactic acid and other bacteria, and various yeasts are concerned in this heating and fermentation. At the end of about 36 hours the temperature is quite high. However, complete fermentation and decay is prevented by the exclusion of the air, and such a result will be found at any point where air chances to enter. The biochemical changes are completed in about 12 days.

Silage is one of the most valuable of feeds in that it is succulent and nourishing, and available in winter or during droughts when other succulent feeds are unobtainable. It is very palatable, being relished by all species of domestic animals as soon as accustomed to the feed. The composition of silage depends largely upon the material and mixtures used in filling and the stage of maturity at which they are cut.

Composition of Silage.[1]

	Water %	Ash %	Crude Protein %	Fibre %	Nitrogen free extract %	Fat %
Corn, immature	79.1	1.4	1.7	6.	11.	.8
Corn	73.6	2.1	2.7	7.8	12.9	.9
Corn, ears removed	73.7	1.6	2.2	6.5	15.1	.9
Sorghum	76.1	1.1	.8	6.4	15.3	.3
Soybean	74.2	2.8	4.1	9.7	6.9	2.2
Cowpea	79.3	2.9	2.7	6.	7.6	1.5
Corn and Soybean	76.	2.4	2.5	7.2	11.1	.8
Teosinte	66.8	4.	2.5	12.3	13.6	.8
Prickly pear2	94.63	1.12	.71	.57	3.19	.08

1. Henry's Feeds and Feeding.
2. Haw. Agr. Expt. Sta. Bul. 13.

It has also a high percentage of digestibility, the figures as given in the Annual Report of the Ontario Station for 1906 being as follows: Protein, 55 per cent; fat, 61 per cent; nitrogen free extract, 74 per cent; and crude fiber, 74 per cent.

It has a laxative effect when fed in large amounts, but some dry feed usually counteracts this action. Cases are on record where moldy silage has caused the death of horses with symptoms similar to those of cerebro-spinal meningitis. While of great value in any ration as stated below, silage can not replace grain feed entirely. In New Hampshire, tests showed that the milk flow was decreased when, beyond a certain limit, the grain was reduced and the silage increased in the feed.

Silos and silage were, in the first days of more common use, thought to be of advantage only upon dairy farms. But later tests have shown that silage is of value for feeding horses, mules, sheep, lambs, beef cattle and poultry.

The sum and substance of nearly all experiments has been that silage increased the gain or rate of gain while at the same time reducing the cost of production. The cost of butter in a herd upon dry feed (in Miss.) was 29.9 cents a pound, while with silage the cost was reduced to 20.9 cents. In Iowa the cost per pound gain on lambs fed mangels and beets was 6.82 cents, while with silage the cost was 5.9 cents. In Texas, in a comparison between silage with a small amount of hay and cotton seed hulls in feeding steers, the cost per 100 pounds of gain was reduced with silage from $10.04 to $7.32, while the amount or rate of gain was nearly identical. In Indiana, in fattening lambs, the addition of silage to a ration of clover and shelled corn did not affect the rate of gain but slightly reduced the cost. At the South Dakota Station, steers fed on silage as a maintenance ration were consuming 70 pounds daily at the end of the trial. They increased in weight but were not fat. In another experiment mangels proved superior to silage in making gains. Numbers of experiments have been made in various places and in comparison with all kinds of roughage, with the result usually in favor of the silage.

The reduced cost of production is due in some cases to a reduction in the amount of grain consumed, and more frequently to the greater gains made and to the lesser cost of the silage, which is figured at $3.00 to $4.00 a ton.

The Capacity of Silos and What Size to Build.

The following table gives the approximate capacity of silos of various dimensions and average weights per cubic foot of

silage at various depths. To find the number of tons in a silo, the contents should be figured from the depth of silage after settling, rather than from the depth of the silo.

Capacities of Silos and Weight per Cubic Foot.

Depth of silage	Inside diameter in feet							Average Weight per cu. ft.
	12	14	16	18	20	22	24	
20 Feet	....	....	66	84	104	126	150	33.3
22 Feet	....	....	76	96	119	144	172	34.6
25 Feet	....	....	89	116	143	173	206	36.5
28 Feet	61	83	108	136	168	204	243	38.4
30 Feet	67	91	119	151	186	225	268	39.6
32 Feet	74	100	135	165	204	247	294	40.7
36 Feet	87	118	155	196	243	289	348	42.8
40 Feet	101	138	180	229	280	338	407	45.
44 Feet	....	....	212	264	320	397	467	48.
50 Feet	....	....	251	318	382	470	565	50.
Wt. of 5"	1885	2575	3350	4250	5250	6100	7535	8850

If one well understands the principles of ensiling it will be seen that deep silos are preferable to shallow ones. The average weight per cubic foot increases with the depth of the silage. A silo should be 2 to 3 times as deep as broad, and as now constructed they average about 2½.

It is necessary to feed off a certain amount each day to prevent loss by molding, and one should calculate from this and from the number of animals he has what size of silo will fill his requirements. For simplicity the average weight of a cubic foot of silage is figured at 40 pounds. If a man has 40 cows and wishes to feed each 30 pounds daily and must feed off 2 inches daily, the problem works out like this:

Amount fed = 1200 lbs. or 30 cu. ft.

30 cu. ft. divided by 2" daily = 180 sq. ft.

180 sq. ft. = the surface area of the proposed silo.

The square root of (180÷.7854)=15 ft.

The diameter of the silo wanted equals 15 feet.

If 2" are fed off daily and the silage is 30 ft. deep, the feed will last about 180 days.

If, in Hawaii, 5 inches must be fed off daily, either one must have narrow silos or larger herds of cattle. In the above example if 5" be substituted for 2" the diameter of the silo required will be found to be less than 10 feet. If, however, a man has 300 head and wishes to feed 25 pounds daily while removing 5", the problem works out thus:

Amount fed = 7500 pounds or 187.5 cu. ft.

187.5 cu. ft. divided by 5″ = 450 sq. ft. or the surface area of silage.

The square root of (450 divided by .7854) = approximately 24 feet = diameter of silo wanted.

From these examples, the reader will be able to calculate the size of silo suited to his particular needs.

Acreage.

The acreage to plant to fill a given size of silo may be determined only after some records have been kept for several years. To divide the capacity of the silo by the average yield per acre and then add 40 or 50 per cent for allowance for dry season, would seem to be a good rule. If any excess seems likely, some may be fed out green as a soiling crop.

The yield of corn should be from 7 to 10 or 11 tons per acre, in order to prove profitable.

Construction of Silos.

The principles upon which silo construction is based have been mentioned in a preceding paragraph. The primary objects of a silo are to exclude the air from the silage and to retain the moisture already found there, or much of it. Other considerations are secondary, yet kind and quality of the building material, durability, cost of construction and maintenance, whether fireproof or not, and appearance should be considered.

For temporary purposes, cheap silos may be satisfactory, but in the long run the more solid structures will prove to be the cheaper. The cost of repairs and often a loss in spoiled silage make cheap silos dear at any price. However, any material which accomplishes the primary objects above mentioned may be used. It must be remembered that strong walls are absolutely necessary for best results. The weight of the silage is supported by the bottom of the silo at the ground, but the lateral pressure when silage is settling must be borne by the walls, and the latter must not warp or bend else air may be admitted. That the lateral pressure in time subsides is proven by the fact that in many cases of fire, the structure of the silo has been destroyed, leaving a circular mass of silage 20 to 30 feet high which retained its shape until some time later, when the silage became spoiled because of exposure to the air.

Prof. King of Wisconsin found that the pressure increased 11 pounds per square foot for each foot in depth, i. e., at 10 feet from the surface the lateral pressure was 110 pounds per square foot; at 20 feet it was 220 pounds; at 30 feet it was

330 pounds, and so on. This explains why it is necessary and important to have proper strength in the walls and especially near the bottom. The walls must be straight and smooth to facilitate settling of the silage and to allow this without the formation of air pockets at the sides. When a silo is filled rapidly, the mass will settle one-fifth or one-sixth of the height in the next four or five days, after which the silo may be again filled to the top. Again, walls of some strength and weight are necessary to resist the wind when they are empty and dry. Many of the cheaply constructed silos have thus been racked out of shape, ruined for the intended purposes, or completely destroyed. Durability depends upon the durability of the materials used and upon the solidity or rigidity of the structure.

*The Foundation.** As in all structures, a firm foundation is necessary—even more necessary, since in a leaning silo there is a tendency for the silage to settle away from one wall.

The thickness of wall depends upon the kind of silo erected. The weight of the superstructure rests upon the foundation, and a larger foundation would be necessary for stone, brick or concrete than for building blocks, frame or stave silos. The width of the "footing" course varies for the same reason.

The walls should extend one foot above the surface and three to four feet below the surface to solid earth, where variations in moisture found at the surface may be avoided. If soil is porous or if in dry regions, probably no drainage will be necessary. Otherwise a tile underdrain, imbedded in gravel or coarse sand, should be placed under the foundation walls and floor of the silo. This drain may open into the floor of the silo, but if so the opening should be well plugged before filling.

Materials. Hard burned brick or stone, laid in cement, or concrete should be used. To lay the stone and pour thin cement mortar in to fill the crevices has been found to be a faulty method. Either lay the wall regularly in a thick mortar or construct a form and put in the mortar first and wet sand and rock afterwards, well tamping the mixutre. The best results, however, can be obtained only when true concrete is regularly made and mixed upon a mixing board, or in a mortar box, or in a machine, before placing it in the form. If the soil is used for one side of the form, it would be well to use tarred paper by it to prevent loss of moisture from the concrete or the entrance of any clay particles into the mixture. Wire, iron rods or woven fencing may be used for reinforcement.

Upon dry clay a floor in a silo is not necessary; with porous

* See Plate I-E.

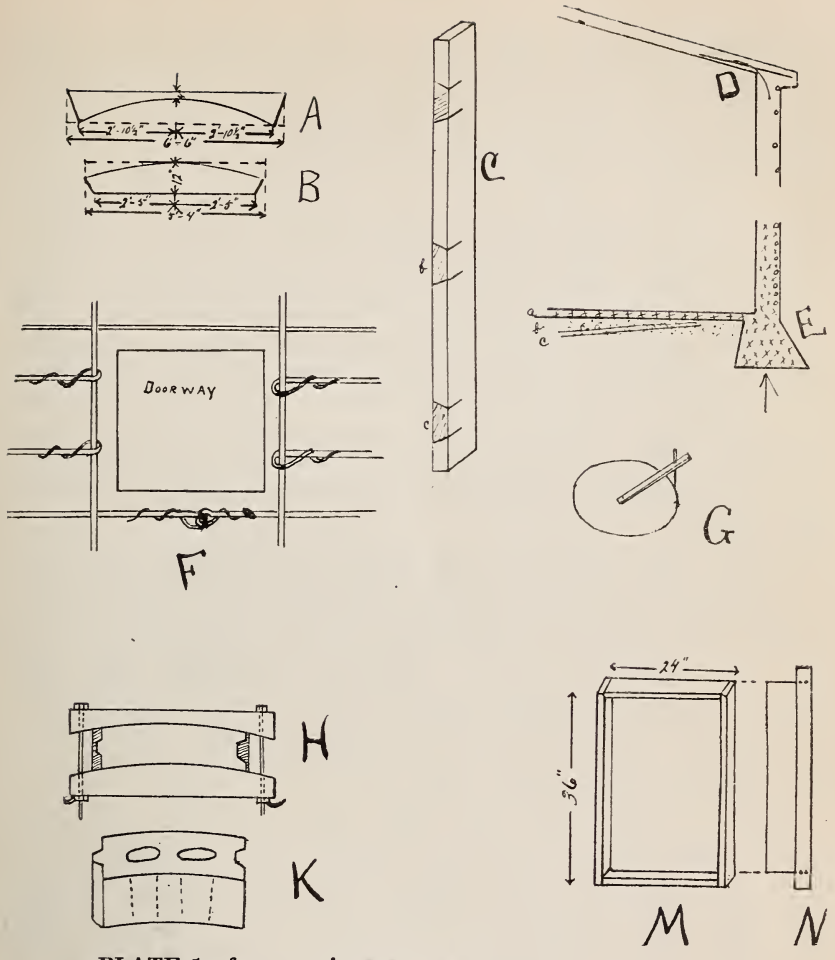

PLATE 1—from various sources.

A shows section of outer form for concrete silo cut from 2″x12″x6′-6″.

B shows section of inner form for concrete silo cut from 2″x12″x5′-4″.

C shows how to start the saw in one stave to make a beveled door for a stave silo; the larger opening should be upon the inside.

D shows reinforced union of roof and wall in a concrete silo, and cornice.

E shows foundation for any silo with a section of wall and reinforcing in a concrete silo. "a" is the floor; "b" is gravelly sand; "c" is tile drain.

F shows one method of reinforcing about the doors in concrete silos.

G shows method of marking circle for foundation or for making forms.

H shows side pieces of form for making cement blocks. The bottom boards and wooden cores are not shown.

K shows a hollow cement block as made in form "H."

M shows section of form for doorway of concrete silo. For 6 inch walls use 2″x6″ material and 2″x8″ material for 8 inch walls. Over M is placed another similar box 28″x40″ made of 2x2 material.

N shows a side view of the completed form. When placed in the wall, the side having the 2″x2″ rim about it is placed upon the inside.

or wet soil it is, and a thin floor is almost always made. One may use less cement in the mixture for the floors. In foundations for wood structures, the walls should extend at least a foot above the surface and a sill with anchor bolts or heavy spikes, imbedded at the surface to which the studs may be securely toenailed. Pieces 2″x4″x2′ may be used. The anchor bolts or spikes extend at least three inches into the foundation below the sill. Long anchor bolts should be inserted back or outside of where staves will come in foundations for stave silos.

The Roof. The roof of a silo is as unimportant as the floor —in other words, it may or may not be necessary. It is necessary in cold climates to prevent the freezing of the silage and in wet regions to exclude heavy rains. Light rains, however, do no damage. The top of the silage is always exposed to the air and air-tightness of the roof is of no avail. The roof adds to the appearance and prevents trash from blowing in, to a slight extent.

A plate may be nailed to the top of the studs or staves, but in masonry silos a plate must be imbedded as described for sills of wood structures. If cement roof is to be put on, plates are unnecessary. Reinforcement connects wall and roof as in Plate I-D. The roof may be conical or pyramidal, with sides sloping toward the highest point at the center; or gable roofs or shed roofs with but one slope may be built. The latter is much simpler and cheaper, but might be more easily lifted by the wind unless securely anchored.

Materials. With shed or gable roof, galvanized iron, tin, roofing paper, cement, slate or shingles may be used. With conical or pyramidal roofs, cement, tin, slate, shingles or possibly paper can be used. In many places in Hawaii it might be convenient and economical to construct merely a framework for a roof and then over this use a canvas curtain which can be taken down after the heavy rains when a roof is no longer necessary. However, after the removal of scaffolding, the placing and removal of the canvas would be attended with some difficulty and danger. Metal lath and cement roofs have been used in some cases and are satisfactory.

For filling the silo an opening must be left or built into the roof. Either a trap door or a dormer window will answer the purpose.

Door for the Silo. The doors should be located in a vertical line for convenience. Some have placed them upon different sides, thinking that the structure is too much weakened when all are in line. Doors at 4 feet apart or 6 to 8 feet from center

to center, will be numerous enough for convenience in feeding. Continuous doors are in use, mostly in some of the "patented" silos. These are put in as silo is filled and removed as it is emptied. The slight advantage they give is that entrance to the silo is more easily made through them and some labor in getting out the silage is avoided.

A chute should be built by the doors down which the silage is thrown in getting out the feed. A cart or wagon may be backed under the chute and the silage loaded without rehandling. A ladder may be built up along one side of the inside of the chute. In its absence portable ladders may be used; or a ladder may be made only between doors; or, in the concrete silo, rods may be imbedded in the concrete which serve the purpose.

The Kind of Silo. There are two kinds of silos, according to placement above or below the surface of the ground. The pit silo was the original silo used in Europe. It is simple, but laborious to construct; requires no foundation or reinforcing or elevation of material when filling, but does necessitate lifting the feed when emptying, and as the larger proportion, by far, of the silage is at the bottom, the work becomes tedious before the silage is all fed out.

. Plastering the sides and bottom with a half inch of cement plaster is all that is necessary after the excavation is made: *i. e.,* where moisture is not excessive and cement will adhere to the walls. In some places a single brick wall is laid up and plastered. A thin concrete wall could also be easily made.

The elevated silo has been found more satisfactory because of the ease in handling the silage. Power machinery is necessary to cut the corn or other feeds used and it takes but little extra power to lift the cut feed to the top of the silo. The placing of improved machines and power for the few days necessary to fill this form of silo, in a comparison with the extra work by hand, or by windlass, or by horse power, for the 150 or 180 days necessary to feed out the silage, results greatly in favor of the use of power for a few days and of the elevated silo.

So great is the objection to lifting silage by hand that doors are made continuous or at intervals of but a few feet from each other, and the bottom is excavated to only a depth of about three feet or four feet below where the first door is to be made, so that never does the silage have to be pitched over four feet high.

Of the elevated type there are many different forms, according to the materials used and the methods of construction.

The Stave Silo. The simplest and cheapest forms are known as stave silos. If well built, the silage in them keeps well. A temporary silo has been constructed very quickly and cheaply by using plain staves without bevel or tongue and groove, and binding these with woven wire fencing drawn tight with stretchers. Such a silo, however, is not durable, since there is nothing to prevent the warping or bending of the staves. The Dairy Division of the Bureau of Animal Industry, in B. A. I. Circular No. 136, recommends plain staves spiked together. Near each end and in a few places along the length of each stave (except where the doors are to be cut out) holes are bored straight into the edge of each stave. When erected, spikes are driven from a certain stave to the adjoining one, being started in these holes and driven home with a drift pin. Prof. Krauss at Kamehameha Schools (Vol. III, Hawaiian Forester) used a common water tank, inverting every other stave so that diameter of the silo at the top would not be reduced below that at the bottom as is the case with many of our stave water tanks.

The staves should be beveled, tongued and grooved; the hoops should be of flat or preferably of round iron and of sufficient number; and then, if well anchored or guyed, and the hoops kept tight, the stave silo will endure and do good work for many years. Being light in weight, anchoring and guying are necessary to avoid damage by wind when they are empty. The staves must be straight-grained heart wood, without knots or windshakes. Redwood, cypress or Oregon fir are durable, but the first named shrinks and swells less when empty or filled. Staves if possible should be of full length, planed on the inside at least to better allow the settling. If to be painted on outside, both sides should be planed. If unable to secure staves of full length, shorter ones may be toenailed firmly together. Steel or galvanized iron "splines" are often used to make the union more perfect. A groove is sawed into the ends of the two staves to be spliced and the spline fitted into these grooves when putting up the staves. The spline should be slightly wider than the staves so as to mesh into adjoining staves. For a 30 foot silo 20 foot staves may be secured and some cut into 10 foot lengths, and then a short piece used first at the top and then at the bottom so as to "break joints," or pieces 14 feet and 16 feet in length may be similarly used. For a 36 foot silo, pieces 16 feet and 20 feet may be used, and so on.

For narrow silos, 12 feet or less in diameter, staves 2"x4" should be used, and for those 14 feet or more in diameter, staves 2"x6" are better; in very large structures it is possible

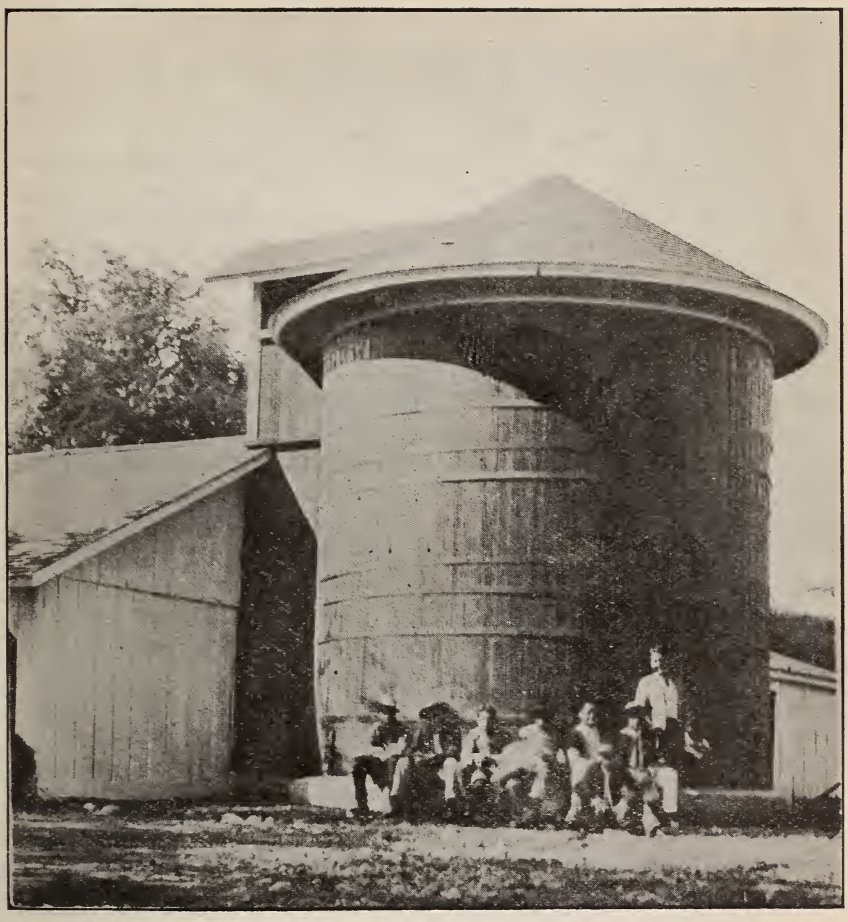

PLATE 2—
Stave silo at Kamehameha Schools—made from water tank staves.

that staves 2″x8″ even could be used to advantage. The hoops should be of ⅝″ round iron preferably, since band iron rusts out more quickly and the staves rot beneath the bands. The rods are more easily handled if in short sections of from 12 to 16 feet in length and should be well threaded at the ends. The lugs should be of cast iron, since the use of wooden lugs results in rotting the wood of the stave and lug, beneath the lug. Because of the lateral pressure, as previously explained, the hoops must be closer to each other near the bottom, or of heavier iron. The lower may be placed 6″ from the bottom; the next, 2 feet higher; the third, 2½ feet above this; the others

at 2½, 3 and 3½ foot intervals, according to the height of the silo.

If the rods are secured by a few staples they will be prevented from falling when the staves dry out and a collapse of the structure may be avoided. However, the nuts upon the rods should be tightened when the silo is empty and staves become dry, and loosened again when the silo is refilled. Unless loosened the expansion of the staves from the absorption of moisture may result in broken hoops. If sufficient hoops are used to insure the proper strength, and if proper attention is given to keep them properly tightened or loosened, the longevity of a good stave silo is insured; otherwise, it may be very short-lived. The Wisconsin Experiment Station advises also the use of a wooden hoop at the top and at the bottom, to which the staves are nailed. This distributes the shrinkage when empty, preventing any large cracks. They also recommend some wooden hoops laid on diagonally as braces to prevent racking out of plumb.

The doors for the stave silos may be cut from the staves. When erecting the silo, one stave, which comes upon the side where the doors are desired, may be sawed partly across at points where the bottom and top of each door is to come.* After the silo is completed the doors can then be sawed out without making auger holes. In starting and cutting out the doors, the cut should be made upon a bevel, so that the inner side of the door will be larger than the outer side; then pressure of the silage holds the door in place and if, when the door is put in at time of filling, the joint is covered with tarred paper or thick plastic clay, a practically airtight joint is secured.

The King Silo. The King silo is the typical "frame" silo. Pices 2″x4″x2′ are imbedded in the foundation wall for sills. Studs 2″x4″, or 2″x6″ in very large silos, are erected at the joints of the sill and secured to a 2″x4″ post placed in the center of the silo. When all are in place, ½″ sheeting ripped from 1″x4″ or 1″x6″ pieces is nailed to the studs. Over this is placed building or tarred paper, then another layer of ½″ sheeting, then another layer of paper and a layer of sheeting, making three layers of wood and two of paper in the lining. Upon the outside one layer of sheeting covered by weather boarding may be used. A cheaper covering is to construct bands around the silo at proper distances of three layers of ½″x4″ pieces (breaking joints properly). To these hoops or bands ordinary

* Plate I-C — a, b, c.

boxing, with or without battens, may be nailed. Galvanized iron could be used in the same manner.

The Plastered or Gurler Silo is a modification of the above, in which the lining is composed of one layer of sheeting covered with wood or metal lath and a coat of cement plaster. This silo has been found to be very satisfactory in service and quite reasonable in cost of construction. The doors for frame silos, and often for stave and masonry silos, are made of two thicknesses of matched flooring with tarred paper between. Upon one face the boards are placed horizontally and upon the other vertically. Either of these frame silos may be used without the outer wall, but, with the latter, especially, a few wooden hoops should be put on. With the studs exposed, however, the structure is rather unsightly.

Proper circulation of air between outer and inner walls for protection against rotting is secured by boring holes through the outer wall at the bottom and inner wall at the top, covering these with wire netting to exclude rats.

The Octagonal Silo. Another modification of the frame silo is the octagonal silo, with 2″x8″ planks used horizontally in place of hoops and serving as nail ties in place of the studs. At the lower part "rims" of these 2″x8″ pieces, nailed together at the ends, are placed at intervals of one foot. Above this they spread to 1½ feet apart and at the top to 2 feet. The inner lining may be made of a good grade of boxing—two layers, with tarred paper between and with joints properly broken so that cracks can not occur. The original silos were square silos, in which there was great loss of silage in corners and along the walls which "sprung" with the pressure. The octagonal reduced the loss somewhat. It marks a transition stage between square and round silos. Only round types are now built.

Masonry Silos.

There are several types of silos in which little or no wood is used in their construction, such as the stone silo, the brick silo, the clay tile silo, the cement block silo and the concrete silo.

The choice of material depends upon availability or relative cost of the same, since, if properly built, just as good a silo may be built with one of these materials as with any of the others.

Where stone is plentiful, it may be used in making a stone silo, or the stone may be crushed and used in making a concrete silo. In many of the states clay is more plentiful than

crushed rock, and brick and tile silos are the more economical. In a section where no clay or rock is available, but where sand is plentiful, it would seem that the cement block silo could be more cheaply constructed.

This type of silo may be constructed with either a solid or a hollow wall. When using clay building tile or certain types of cement blocks no extra labor or care is necessary to construct a wall which is more or less hollow, but with concrete, special forms are necessary; and with brick, care must be taken to keep the outer and inner walls well bonded together.

Since there is no possibility of silage being frozen in Hawaii, it would seem that the only advantage of a hollow wall might be in a reduced cost of construction, less material and labor being required.

The Monolithic or Concrete Silo. This form of silo is probably the one best suited to Hawaiian conditions and materials. Sand and rock are easily obtained and men skilled in the making of forms and in handling concrete are almost always available. When white sand is not available, the black or volcanic sand may be used. However, before being used, it requires several washings for the removal of the clay which is intermingled with it. Upon the Parker Ranch one silo was made using black sand, but in later ones finely crushed rock was used, to avoid the work necessary to wash the black sand. To obtain this material, besides the regular rock crusher and screens, a separate small crusher operated by a separate engine is used.

The mixing of the concrete may be done in a power machine, a hand machine, or by hand upon a mixing board. The proportions used are generally 1 part of cement, 2 parts of sand and 4 parts of gravel; but this may vary under varying conditions, such as different thickness of walls, the amount of reinforcement, or the cleanness of the sand and gravel; 1—1½—3 and 1—2½—5 formulae being sometimes used.

The Amount of Materials for Concrete Construction. Bulletin No. 214 of the Wisconsin Experiment Station gives the materials necessary for a silo 14x36 feet with 6″ wall as follows:

Mixture 1—2½—5.

SILO PARTS	Cement bbls.	Sand cu. yds.	Gravel cu. yds.	Concrete cu. yds.
Foundation footings	1.87	.77	1.54	1.75
Floor	2.67	1.1	2.2	2.5
Foundation wall 4 ft. high	7.46	3.07	6.14	6.98
Wall 32 ft. high	28.99	11.92	23.74	27.1
Roof	3.21	1.32	2.64	3.0
Total	44.2	18.18	26.22	51.33

Note:—If the sand and gravel are clean and care is exercised in mixing, a 1—2½—5 mixture is sufficient. If not, use a 1—2—4 mixture, in which case add 7 bbls. cement, 1 cu. yd. sand, and 1.1 cu. yds. gravel.

For estimating the amount of material in silos with other dimensions the following tables and directions are given in the same bulletin:

Materials for One Cubic Yard Concrete.

	Mixture 1-2-4	Mixture 1-2½-5
Bbls. cement per cu. yd. of concrete	1.3	1.07
Cu. yds. sand per cu. yd. of concrete	.42	.44
Cu. yds. stone per cu. yd. of concrete	.84	.88

*Materials per Foot in Height of Silos.**

Mixture to be one part cement, 2½ parts sand, 5 parts gravel, and wall to be 6 inches thick.

Diameter	cement	Sand	Gravel
Feet	Bbls.	Cu. yds.	Cu. yds.
10	.65	.269	.538
12	.778	.32	.642
14	.903	.372	.74
16	1.03	.422	.844
18	1.16	.475	.95
20	1.27	.525	1.05
22	1.4	.576	1.15

Forms for Concrete Silos. At least the outside form must be of small dimension (height), otherwise an unnecessarily high lift of material would have to be made. A cheaper form can be made when the inside form is built in a similar manner—but the inside wall may not be vertical unless great care is observed in adjusting the inside forms.

* These figures do not include ROOF, FLOOR or FOUNDATION.

Where many silos are to be built, the labor of moving the inside form may be avoided, and the cost thereof offset by the use of the more expensive continuous inside form—which also insures a vertical wall.

The materials and methods of construction for forms for a 6″ wall of a 14′ silo are thus given in the bulletin above quoted:

Main Frame—16 pieces 2″x12″ 12′ long No. 1 pine.

Outside Form—4 pieces 2″x8″ 10′ long No. 1 pine; 6 pieces 2″x6″ 10′ long No. 1 pine.

Inside Form—4 pieces 2″x6″ 10′ long No. 1 pine; 6 pieces 2″x4″ 10′ long No. 1 pine.

Connections—4 pieces 2″x8″ 10′ long No. 1 pine.

Roof Form—8 pieces 2″x4″ 18′ long No. 1 pine; 4 pieces 2″x8″ 14′ long No. 1 pine; 2 pieces 1″x6″ 14′ long No. 1 pine; 1 piece 2″x4″ 11′ long No. 1 pine.

Door—1 piece 2″x6″ 10′ long No. 1 pine; 1 piece 2″x2″ 10′ long No. 1 pine.

Nails—15 pounds 20d wire spikes; 5 pounds 6d wire nails.

Bolts—Outside Form—16 ½″x4½″ carriage bolts.

Bolts—Inside Form—96 ½″x4″ carriage bolts.

Galvanized Sheet Iron No. 18—8 pieces 6′ long by 2′ 6″ wide; 8 pieces 6′ 6″ long by 2′ 6″ wide.

The 16 pieces 2x12 inches 12 feet long should be cut so that two pieces will be obtained, one 6 feet 6 inches long and the other 5 feet 4 inches long. These pieces are for the outside and inside forms. To lay off the circle for the form, select a level place in the shop or barn, take a narrow strip of wood 1½ or 2 inches wide and 8 feet long, bore a hole in one end of the size of a lead pencil, measure from the center of this 7 feet 6 inches and drive a nail through. This will make the outside circle. Since only one-eighth of the circle is required, it will not be necessary to make a complete circle at this time. The inner circle is made in the same way by shortening the distance 6 inches between the nail and the pencil.*

Two patterns are necessary—B, Plate 1, for the inside form, and A, Plate 1, for the outside form. For the outside form, take one of the pieces 6 feet 6 inches long. Using a steel square, locate the center on one side. From this center lay off 2 feet 10½ inches each way. Place this edge of the piece toward the center of the circle, and under the 8 foot arm which was prepared for drawing the circle. With the pencil at one of the points just made, draw a curved line to the other point.

** Plate I-G.

This will be one-eighth of the outside circle as shown at D in Plate 3. Cut this piece as shown at A in Plate 1, and the pattern for the outside is complete. Cut 16 of these pieces and they are ready for framing into sections.

Take one of the 16 pieces 5 feet 4 inches long, as shown in B, Plate 1. The center is then determined as before. Measure off 2 feet 5 inches each way from the center. Lay this piece under the 8 foot arm, and with the pencil 6 inches nearer the center of the circle, draw a curved line from one end of the piece to the other. This will be one-eighth of the inside circle as shown at C, Plate 3.

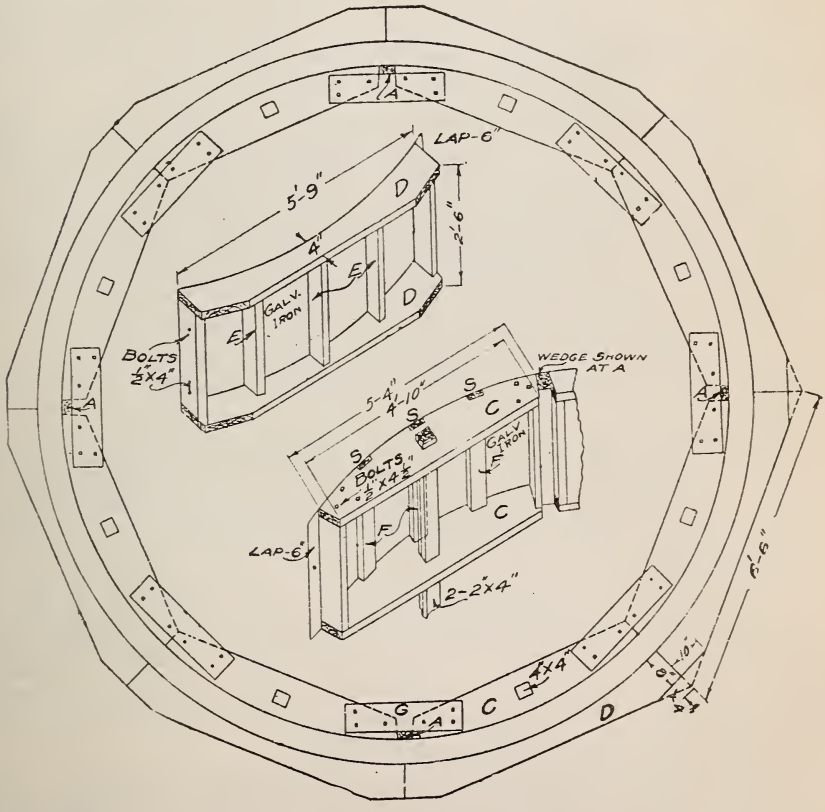

PLATE 3—

Sections C and D shown in circular position as they would appear from above. Note the wedges at A. These should always be released and the connections at these points unbolted when raising the forms preparatory to filling.

To complete the construction of the outside form, take four pieces of 2x8 inches 10 feet long, and six pieces 2x6 inches 10

feet long and cut them into studding 2 feet 2 inches long, as shown at E in Plate 3. Then spike the D's and E's together, using 2x8 pieces at the ends, and the frame is ready to be faced with No. 18 galvanized iron. Care should be taken to square the frame before nailing the iron on. Use six penny wire nails for this purpose.

The studdings as shown at F, F, F, Plate 3, for the inside form are the same except that they are 2 feet 6 inches long. The framing of this form is the same as in the outside form, except that three center studdings are mortised into the inside frame as shown at S, S, S, in Plate 3.

Cut 4x4 openings as shown in C, Plate 3. These openings are for the two pieces, 2x4, used to support the inside frame. By breaking joints these supports may be raised to the height of the silo. They must always be perfectly plumb.

The sections should be set and bolted together in a circle, placing the inside form first. To do this, describe a circle with a pencil and arm as before explained. From the four pieces 2x8 inches 10 feet long make 16 connections 2 feet 6 inches long, and bolt one at top and bottom of each section as shown at G, Plate 3. A second circle 6 inches outside of the other should then be drawn and the sections of the outside form set in place as shown at D in Plate 3. To keep the outside form just 6 inches from the inside form, make up several pieces 6 inches long for spacers. These should be placed 4 or 5 feet apart.

For 16, 18, or 20 foot silos the forms are constructed in the same manner, but the dimensions of the various pieces will of course be different. Lay off the circle upon the ground; divide it into eighths, and cut the inner and outer forms to meet at the dividing lines.

*Reinforcement of Concrete Silos.** The material used for strengthening concrete silos is of various kinds. In the Oklahoma Farm Journal for February 15, 1913, a writer mentions using, with 3 foot forms, a 34" woven wire fencing. Each fill was 32 inches, so that the fencing was lapped two inches and no weak point occurred between fillings.

Upon many of the farms in the West, there is usually a surplus of worn out farm machinery, some portions of which are always available for reinforcing. Iron rods ⅜"-⅝" in diameter are common commercial forms for reinforcing. In the absence of other materials or as substitutes for them ordinary smooth No. 9 wire may be used in the form of cables. Barbed wire

* For reinforcement about doorways see Plate I-F.

could be used and would perhaps be better, but it is difficult to handle. Wire cables are easily made in any length desired and afterwards they can be cut into shorter pieces. Take a heavy wagon and raise one wheel upon a wagon-jack or block and brace thoroughly so as to prevent any movement forward, backward or to the side. At the desired distance from the wagon set a heavy post and attach to it the ends of several wires. The wires are then attached to every fourth or fifth spoke upon the movable wheel, near the hub. Upon turning the wheel the wires are soon twisted into a cable. Rods and cables should be placed near to the outer edge rather than to the inner edge of the wall.

In silos over 25 feet high, vertical reinforcement should be employed as well as horizontal. Three-eighths inch rods at intervals of 15 to 30 inches are recommended, but not always used. If cut into short lengths, rods or cables can be more easily used as vertical reinforcement.

Concrete, because of the strength of the cement, requires less reinforcement than stave, brick, tile or block silos.

The following table, from Wisconsin Bulletin No. 214, gives the approximate amount of reinforcement to use.

Amount of Reinforcement Needed for Silos.

Size and Spacing of Horizontal Reinforcement Around Sides.

Distance in Feet Measured From Top of Silo	For Silos 14 ft. to 18 ft. in Diameter, Using No. 9 Wire		For Silos 14 ft. to 18 ft. in Diameter, Using ⅜ Inch Mild Steel Rods	
	No. of Wires in Cables	Distance Apart of Cables	No. of Rods	Distance Apart of Rods
		Inches.		Inches.
0- 5	2	12	1	18
5-10	2	10	1	18
10-15	2	8	1	14
15-20	4	8	1	12
20-25	4	6	1	10
25-30	4	6	1	8
30-35	5	6	1	6
35-40	5	4	1	4

If there is a scarcity of reinforcing material, the lack may be made up by using a greater proportion of cement in the mixture, or by making a thicker wall.

Upon the Parker Ranch on Hawaii are now being constructed several concrete silos. The forms in use may be described as follows: The outer form is similar to the one de-

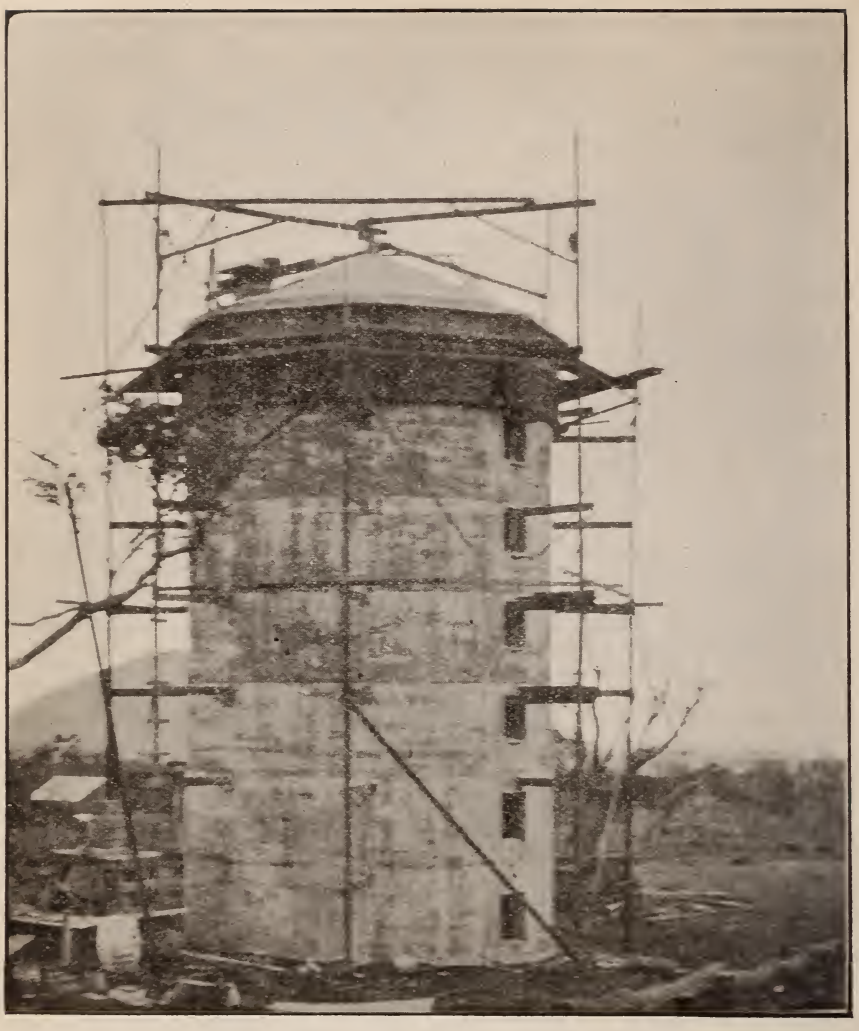

PLATE 4—
Concrete Silo on Parker Ranch. Dimensions 20′x40′.
Concrete mixing machine in view, at left.
Scaffolding in place. Outer form still on at the top.
Roof nearly completed.

scribed and illustrated above with the exceptions that vertical staves of 1″x4″ shiplap are used in place of the galvanized iron, and the form is 5′ high in place of 3′. Only two 2″x4″ studs are used upon each section with the shiplap where more were necessary with galvanized iron.

All the joints are made secure by bolts as shown, but one.

At this one two large bolts 30″ long are used. These bolts are placed horizontally, one near the top of the form, the other near the bottom. The form may be loosened when desired by unscrewing the nuts of these bolts. Then the form is raised by four sets of pulley blocks hung from the scaffolding and the bolts are tightened, after which everything is ready for another fill.

The inside form is made of shiplap 1″x4″ by 20′ with braces, made as described, occurring at bottom, at 10 feet high, two at 20 feet where the upper section meets the lower, another at 30 feet, at 35 feet and at 40 feet.

The dimensions of these silos are 20x40 feet with an 8 inch wall the entire height. The capacity of each is nearly 300 tons.

The scaffolding consists of 4x4 inch post in the center of the silo, several 4x4 inch and 3x4 inch posts upon the outside. These outer posts are connected to the inner one at intervals by 1¼x6 inch pieces and across these the platforms are constructed, the entire scaffolding being well and securely braced so as to avoid accidents. The inner form is well braced also from the inner post.

The Iowa or Hollow Clay Tile Silo.

This silo is simple in construction, durable, efficient, and reasonably cheap where the tile can be obtained. It is built of regular clay, hollow building blocks 4″x8″x12″ or of dimensions approximating these. The tile are laid in cement mortar which contains just enough lime to make the mortar stick well, (1 part cement, 1-3 part lime, 2 to 3 parts sand). No. 3 wire is laid in for reinforcement, the amount of wire used being adjusted to meet the demands of the lateral pressure. The inside of the tile may be plastered—or simply washed with a cement wash.

The Concrete Block Silo.

When once the concrete blocks are made, the construction of this form of silo is the same as that for the one preceding. In the manufacture of the blocks, a form consisting of a bottom board, and hinged or bolted side pieces are used.* From one to five of the side pieces or frames are necessary while thirty to fifty of the bottom pieces are required. In making cement blocks as in making posts but little water is used because with little water, the material soon hardens and the side frames may be removed and used in making more blocks.

* See Plate I, H and K.

In order not to disturb the cement until set, the block must be left upon the bottom board for some time, at least 3 to 4 days, and hence more of these bottom than of side pieces are necessary.

The properly "cure" blocks made in this manner, a period of at least three weeks is necessary, during which the blocks must be kept from drying too rapidly. They are sprinkled well and frequently, and covered with old hay, straw, sacks or with tarpaulins to protect them from the sun. By having several of the side forms, immediate removal of the form is unnecessary, more water can be used and a stronger block obtained.

A convenient size of block is 8"x8"x24". To make these as light as possible and to save material the Wisconsin Station advises the use of two cores 2" thick, 8" long and 6" wide—tapered toward one end so as to be easily removed.

Forms for making such blocks are inexpensive and any one can make them. Concrete block machines are more expensive but permit more rapid work in making.

For reinforcement 3-8" iron rods are used between each layer up to 15 feet after which a less number may be used. Michigan Experiment Station Bulletin No. 255 fully describes several different block silos. One of these may be briefly described as follows:

Silo—16½ feet diameter. 28 ft. high above concrete foundation.

Blocks—9"x36" and 10", 8", or 6" thick.
12 tiers of hollow block 10" thick.
14 tiers of hollow block 8" thick.
12 tiers of solid block 6" thick at top.

Cores for making hollow blocks—2"x10"x9" (tapering).
Concrete—1 part of cement, 5 parts gravelly sand.
Mortar—1 part of cement, 2 parts sand.
Plaster (½")—1 part of cement, 2 parts sand.
Wash—Cement and water.
Reinforcement—No. 8 wire.
Time to build—3 weeks[1].
No. of blocks—700 (1 bbl. of cement to 16 eight inch blocks).

Another type of silo is described as follows:
Blocks—solid—8"x24" by 3" thick.
Doorways—continuous—no door frame.
Reinforcing—2" band iron hoops as for stave silos with 1½"

1. No data given as to time required to make the blocks. In another description it is stated that 3 men could make daily 100 blocks 8"x10"x32".

x4" pieces across doors, under the hoops, to hold wall, and to which supports for a chute are nailed. Hoops 33" apart. Concrete, mortar, and plaster—as usually made and a cement wash was put on over the plaster.

The unique features are the thinness of the walls, and the hoop reinforcing, no wires being used in the walls. Also much less material is required and cost is reduced. The contract price of this silo—with foundation, and frame, rubberoid roof was $176.00 and it had been in use five years at time the bulletin was published.

Steel silos are now upon the market but no reports as to their efficiency are as yet available.

Care of Silos.

For concrete silos, care consists of washing the inner surface every 3 or 4 years with a cement wash. Wood silos may be painted on the outside at intervals as necessary.

Interior walls may be painted only with hot gas tar or creosote.

Plastered silos may be given the cement wash.

Stave silos should be watched. The staves should be tightened or loosened as before stated.

When well built—silos require little subsequent attention.

CROPS FOR THE SILO.

The corn plant is preeminently the one for silage. It furnishes nutritious feed, good yields per acre, ease and cheapness in handling, and a wide adaptability to climate and soils. Other crops can be used alone or in mixtures, but none can ever replace corn entirely. Alfalfa, clover, cowpeas, soybeans, sorghum, Japanese cane, and other crops have been used. In New York state corn and soybeans have been quite a popular mixture; sorghum and cowpeas make a better soiling food throughout the South and could be used as a mixture for silos. Sorghum and velvet beans also make a good silage according to the Florida Station. Velvet beans alone do not make good silage and the silage from soybeans is very foul smelling.

In Hawaii we have several crops which could be tried out for silage. Corn, alone, or with soybeans, cowpeas or alfalfa will probably be found to be superior to other crops. Sorghum, alone or in mixtures will prove to be of value. Cane tops, where they can be obtained without too great an expense in hauling, should prove successful as silage. Honohono, Para grass, alfalfa, soybeans, cowpeas, velvet beans, jack beans,

teosinte, clovers, and other crops will no doubt keep well and succeed as silage crops.

It is well of course to try and grow some legume to mix with corn, sorghum or other grasses in the silo. The yields of soybeans are not satisfactory at all times; aphids interfere with growth of cowpeas; cutworms kill peas and beans at various times; alfalfa is not suited to all our varying conditions; jack beans and velvet beans are rather slow in growth. Experience alone will enable one to determine which legume is best suited to his particular needs. Ti leaves and prickly pear are feeds which could be tried out. However, the latter feed is succulent and green at all times and might not be improved by ensiling, and the labor bill would be unnecessarily increased.

Marsh rice, cut in the green stage, could be tried along the coasts and perhaps in rainy districts the upland rice would give good yields and feed. A rainfall of at least 10 inches per month is necessary for the best growth of this rice. Egyptian clover has done very well at the Experiment Station and where rainfall is plentiful during winter months, might be grown for mixed silage. Red clover might succeed at higher altitudes. Cowpeas will likely prove to be the better legume under all conditions.

Professor Krauss at Kamehameha succeeded well with corn, sorghum and cowpeas and with cowpeas alone. Vines like cowpeas or velvet beans are somewhat difficult to run through the cutter alone. They should be mixed with twice or three times a like amount of sorghum or corn.

Japanese Cane. Florida Station Bulletin No. 105 gives a good recommendation for Japanese cane as a forage and silage crop. It is given special mention here as worthy of trial where there is a reasonable amount of rainfall at lower or medium elevations. It should be planted in rows about 6 feet apart and it will make several ratoon crops like the regular sugar cane. It will be eaten fresh or as silage by all kinds of domestic animals. It will furnish a much larger quantity of forage, richer in carbohydrates, but poorer in portion, than will corn or sorghum.

YIELDS.

Corn. Carrier (Farmer's Bulletin No. 292) found that the average yield over a considerable area in Michigan and Wisconsin was 9.1 tons green feed per acre. In Nebraska 18 acres of corn (estimated to make 60 bushels per acre)) were required to fill two 110 ton silos, which equals about 12 tons. The Pennsylvania Station also estimates a 60 bushel corn crop at

12 tons and a 40 bushel crop at 8 tons per acre. Maximum yields of corn are 15-18 tons per acre, the yield being obtained by dividing the number of bushels the land will produce by five. A test row from a plot in Nuuanu Valley yielded at rate of 9.8 tons in March, 1913.

Sorghum. Sorghum in Florida yielded better than corn and varied from 8 to 16 tons per acre. Rattoon crops, if moisture is available, would give sorghum a preference over corn. In Hawaii yields of from 5 to 24 tons have been obtained. One variety has exceeded this. All sorghums grow slowly during the cooler months.

Japanese Cane. Japanese cane in Florida gave 16 to 27 tons in 1909 and 10 to 16 tons in 1910. At Mountain View (Olaa Plantation) Hawaii, yields of over 50 tons per acre were obtained for two years, after which much less was obtained.

Teosinte yielded less than sorghum in Florida but in Louisiana 50 tons per acre were obtained. At the Hawaii Experiment Station it yielded about the same as sorghum and made no rattoon.

Jack Beans. Yields at the rate of 11 to 12 tons per acre have been obtained at the Hawaii Experiment Station. P. M. Pond secured one crop of 20 tons per acre, but could not duplicate it.

Velvet beans upon a small plot yielded at the rate of 19.8 tons per acre.

Cowpeas yield 5 to 10 tons per acre.

Alfalfa will make from 2 to 8 tons per acre, per cutting.

Of soybeans, clovers, etc., no yield under Hawaiian conditions are available. It will likely be less than for the cowpeas, jack beans or velvet beans. Yields of course are very variable and uncertain. The nature of the soil, its water holding capacity, prevalence of winds, amount of sunshine, humidity of the air and the adaptability of the crop to the given conditions are some of the factors which determine yield.

Cost and Value of Silage. The cost of silage includes the cost of growing the crop, the rent of the land, the cost of filling the silo and some proportion of the cost of the silo, the feed cutter, etc., the estimate of the latter being based upon their longevity. By calculating the cost and dividing by the number of tons in the silo, the cost per ton will be obtained. The value of silage is really the value of other feeds which one would have to buy to obtain the same result were the silage not on hand. Most of the experiment stations in the States in figuring the result of feeding tests estimate silage as worth $3.00 to

$4.00 a ton. One experiment station values silage at $3.50 per ton or what would be seventy cents per bushel for corn. As the average estimates are that a "5 bushel" corn will make 1 ton of silage, the approximate value of silage per ton is obtained by multiplying the price per bushel of corn by five.

FILLING THE SILO.

The crop should be left in the field until nearly mature—until the leaves show by a yellow color that maturity is near. With corn, the best stage is when kernels are in the "dough." Sorghum may be left until more fully mature. Better silage is made from maturing crops and better yields are obtained.

Corn and sorghum may be cut with a binder (or harvester as some call it) if they have been grown in rows. However, if blown down badly, hand labor must be used. The cost of cutting by machinery is not much less than by hand labor, but the bundles are much more easily and quickly loaded on wagons and unloaded at the cutter making a saving of time. One third more corn can be handled in a given time in bundles. It is well to haul a few loads and stack by the cutter in such place as will not interfere with the approach of the wagons. Then if there is any delay in getting fodder in from the field, corn may be secured from this stack to keep the cutter running. It is best, although not necessary, to fill the silo as expeditiously as possible, once the work has started. After the silage is well settled or after 4 or 5 days the silo may be refilled. Several refillings are necessary. The settling may be facilitated by thoroughly wetting the upper foot of silage to increase its weight. When finishing filling (the final filling) weeds, grass, cornstalks without the grain and any other materials may be used, wet down as described; since the top is exposed to the air and will spoil, poor material answers as well as good. When opening the silo to begin feeding some ten or more inches at the top will be found to be spoiled and must be thrown away.

It is possible to ensile partially dried corn fodder by adding water to the cut material upon the elevator, one-half barrel or less to the wagon load of fodder. There is a tendency because of the difference in their weight for the cut pieces of cob, stalk and leaves to segregate. One man should be kept in the silo when filling, whose duty it is to keep these well mixed, and to keep the silage well tramped near the walls. The mass in the center settles well without tramping, but friction along the walls retards settling and hence the need for thorough tramping at the edges.

Fermentation starts immediately and when resuming the work of filling after any interval the machine should be run several minutes before any one enters the silo. Carbon dioxide develops and accumulates in the bottom but will be dissipated by the falling silage. Especially in pit silos should care be observed.

Cutter. Use one of large capacity rather than a small one. There will be less trouble and delay and the cost of filling the silo will be reduced if large capacity machines are used. To elevate the silage the cutter may be equipped with either an elevator or a blower. Blowers are to be preferred especially for high silos, but much more power proportionately is required. Force feed (or self-feed) machines have a greater capacity for same size of knives. There is less danger of injury to the feeder or to the machine with these machines, since in any emergency the feeding device may be instantly disengaged and stopped without stopping the cutting part of the machine. The exact size to which the feed is cut is of but little importance—uncut feed would keep if it could be packed tightly enough to exclude the air.

Wagons. For convenience in hauling in the fodder from the fields either a low wheeled "handy" wagon may be used or ordinary wagons with extended "drop frame," reaches, so that the main rack or platform is low and convenient between fore and hind wheels. To build this frame two pieces of 3"x12" or other heavy material about 16 feet long are fitted together making a narrow "V" wedge. The point of the "V" is hung below the forward axle by a heavy bolt which replaces the "King" bolt. The open end of the wedge is suspended below the rear axle to which it is attached, the "hounds" being attached to this frame which substitutes for a "reach." Over the heavy timbers a floor, a front standard and a rear standard are built to hold and retain the fodder.

The labor required in filling a silo is considerable. Several men are necessary in the field to cut and load the corn, two or more teamsters in hauling, two men to unload and feed the cutter, one man inside the silo and at least another to attend to the engine. If steam power is used, or if water is necessary to dampen dry fodder, a man to haul water is also required.

The cost of filling in Wisconsin and Michigan, according to Carrier, varied directly with the size of loads that were hauled, and with the distance. Accordingly then, a low cost in filling will be obtained by locating the silo near to the cultivated fields and below them so that maximum loads may be hauled.

Carrier found the cost per ton upon 31 farms to be $0.64 and the cost per acre to be $5.98. In Nebraska the cost was found to be from $1.75 to $1.95, while in New Jersey it was $1.30.

FEEDING SILAGE.

As stated above, when feed is desired, remove the spoiled portion at top and then a few inches each day so that no silage will be exposed sufficiently long to spoil. Professor Krauss found in his experience with the first silo in Hawaii at the Kamehameha Schools that about six inches must be removed daily to avoid loss by molding. Feed small amounts until animals become accumstomed to it. As the silage is laxative in its effect, several pounds of dry feed should be fed with it. Frozen silage causes scouring in cattle and moldy silage is thought to have killed nine horses out of eleven in one instance —the horses showing symptoms of cerebro-spinal meningitis.

Tainted milk will be noticed from cows fed on silage unless they are fed after milking, and unless the stables are kept clean and well aired, and the milk cared for and removed before feeding the silage. The amount of silage to feed depends upon the species of animal and the purpose for which they are fed. Cattle fed for maintenance will consume from 20 pounds to 70 pounds daily depending upon the amount of other feed fed, and the weight of the animals. Cows in milk—receiving "full feed" will consume 35—45 pounds daily.

Fattening steers may be fed:

First periods without grain.....	50-70 pounds.
First periods with grain.....	25-45 pounds.
Last period with grain.....	15-35 pounds.

Horses and mules received 21-30 pounds with grain at North Carolina Station (Bul. 189) and worked full time and gained slightly during the experiment.

Fattening lambs—5 to 8 pounds with grain. Lambs consume about as much hay as silage if offered both. Cattle, however, consume much large quantities of silage.

Conclusion. That silos are a success and of great value to stockmen has been well demonstrated elsewhere. That they are of value under Hawaiian conditions has been demonstrated at Kamehameha School and upon the Parker Ranch, and in an experiment with an old cistern in Kula. By the use of the silo it is certain that a supply of feed may be held over from times of good growing weather to times of drouth. This means a step in advance over the present system in which at times great losses occur.

References:

Annual Report of the Ontario Experiment Station, 1906.

King's Physics of Agriculture.

Henry's Feeds and Feeding.

Hawaiian Forester & Agriculturist Vol. III.

Bureau of Animal Industry, U. S. Dept. Agriculture, Cir. 136.

Iowa Experiment Station, Bulletins Nos. 100, 117.

Illinois Experiment Station, Bulletin No. 102.

Cornell Experiment Station, Bulletin Nos. 167, 310.

Florida Experiment Station, Bulletin No. 105.

Texas Experiment Station, Bulletin No. 153.

Maryland Experiment Station, Bulletin No. 129.

Indiana Experiment Station, Bulletin No. 162.

South Dakota Experimental Station, Bulletins Nos. 137, 163.

Pennsylvania Experimental Station, Bulletin No. 118.

Wisconsin Experimental Station, Bulletins No. 125, 214.

Michigan Experimental Station, Bulletin No. 255.

North Carolina Experiment Station, Bulletin No. 189.

Farmer's Bulletins (U. S. Dept. Agr.) No. 292.

Missouri Experiment Station Circulars Nos. 48, 49.

Addresses of Manufacturers:

Of silage cutters.

Silver Mfg. Co., Salem, Ohio.

Smalley Mfg. Co., Manitowoc, Wis.

Of steel silos.

The Boardman Co., 501 Culbertson Bldg., Oklahoma City, Oklahoma.

Of stave silos.

Indiana Silo Co., 328 Silo Bldg., Kansas City, Mo.

Western Silo Co., 200 11th St., Des Moines, Iowa.

Des Moines Silo and Mfg. Co., 505 New York Ave., Des Moines, Iowa.

Puffer Hubbard Mfg. Co.

Wood Brothers Silo and Mfg. Co., Spokane, Wash.

Southwest Silo Co., 113 California Ave., Oklahoma City, Oklahoma.

Pacific Tank and Silo Co., Chehalis, Wash.

Of tile silos.

National Fire Proofing Co., Huntington, Ind.